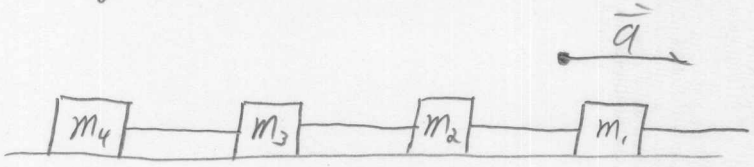
Force Homework Packet

Penguins



$m_1 = 20\,kg$ $\quad T_1 = 222\,N$

$m_2 = 15\,kg$ $\quad T_2 = ?$

$m_3 = ?$ $\quad T_3 = 111\,N$

$m_4 = 12\,kg$ $\quad T_4 = ?$

Surface is frictionless so I'll ignore N and mg.

FBD

NSL

① m_4: $T_4 = m_4 a$

② m_3: $T_3 - T_4 = m_3 a$

③ m_2: $T_2 - T_3 = m_2 a$

④ m_1: $T_1 - T_2 = m_1 a$

The system is linked by ropes so a is the same for all penguins.

We want m_3, so we'll eliminate T_2, T_4, and a

use eq ③ and ④ to eliminate T_2:

$T_2 = T_3 + m_2 a$ $\qquad T_2 = T_1 - m_1 a$

⑤ $T_3 + m_2 a = T_1 - m_1 a$

continued ↓

Penguins continued

use eq ① and ② to eliminate T_4

$$T_4 = m_4 a \qquad T_4 = T_3 - m_3 a$$

$$m_4 a = T_3 - m_3 a \quad ⑥$$

Re-arrange ⑤ and ⑥ to get a on one side

$$-T_1 + T_3 = m_2 a + m_1 a \qquad T_3 = m_4 a + m_3 a$$

$$T_1 - T_3 = a(m_2 + m_1) \qquad T_3 = a(m_3 + m_4)$$

divide

$$\frac{T_1 - T_3}{T_3} = \frac{\cancel{a}(m_2 + m_1)}{\cancel{a}(m_3 + m_4)}$$

Isolate m_3

$$(T_1 - T_3)(m_3 + m_4) = T_3(m_2 + m_1)$$

$$T_1 m_3 + T_1 m_4 - T_3 m_3 - T_3 m_4 = T_3 m_2 + T_3 m_1$$

$$m_3(T_1 - T_3) = T_3 m_2 + T_3 m_1 + T_3 m_4 - T_1 m_4$$

$$\boxed{m_3 = \frac{T_3(m_1 + m_2 + m_4) - T_1 m_4}{T_1 - T_3}} \qquad m_3 = \frac{111(20+15+12) - 222 \cdot 12}{222 - 111}$$

$$\boxed{= 23\ kg}$$